

4. ANALYSIS OF RETRIEVAL AND TREATMENT ALTERNATIVES

Figure 11 depicts the general process used to evaluate Pit 9 retrieval and treatment alternatives. The analysis considered a wide range of design alternatives and narrowed them down through objective evaluation of benefits and risks. First, key performance requirements were developed and documented in the “Mission Analysis and Definition” document (see footnote e). Next, technology research and brainstorming were used to identify applicable ideas and alternatives for accomplishing Pit 9 objectives. Alternatives were screened on a gross scale. The remaining viable concepts were developed further.

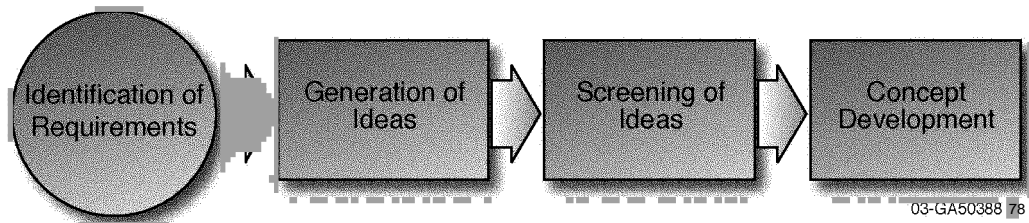


Figure 11. Process flow of the alternative evaluation process.

The rest of this section details the alternatives analysis process for retrieval and treatment.

4.1 Retrieval

The retrieval portion of the Pit 9 Remediation Project provides the systems and structures needed to safely retrieve material from Pit 9 in a manner that is protective of human health and the environment and fulfills the following functions:

- Retrieve waste and soil
- Remove and transport material to characterization
- Stabilize waste left in the pit
- Receive waste from characterization and treatment and return it to the pit
- Install clean underburden and overburden layers
- Confine hazards.

4.1.1 Selection Process

The retrieval selection process considered a wide range of design alternatives and narrowed them down through objective evaluation of benefits, cost, schedule, and risks. The following process was used to complete the alternative selection.

1. Key performance requirements were developed and documented in the Pit 9 “Mission Analysis and Definition” document (see footnote e)
2. Technology research and brainstorming were used to identify applicable alternatives available for waste retrieval equipment and facility design (EDF-4025)

3. Applicable alternatives were **screened on a gross scale** in a value engineering process to determine viable alternatives. Three of these alternatives were chosen for **further** study based on a performance criteria evaluation (INEEL 2003a).
4. A preconceptual design **was** developed for the three alternatives, while the Pit 9 team simultaneously agreed on a **set** of evaluation criteria and weighting factors that included technical, cost, schedule, and risk criteria. Each alternative was rated relative to each evaluation criterion, and weighting factors were applied to the criterion-specific ratings for **each** alternative. The **sum** of these weighted evaluation criteria ratings yielded **a** total score for each alternative (INEEL 2003a).

Initially, 21 retrieval facility alternatives and 60 equipment excavation and transport alternatives were evaluated. **As** part of the down selection process the factors of cross contamination, contamination spread, implementability, and schedule were considered. Independent of the facility **and** retrieval equipment alternative selected, the team established that contamination spread within the retrieval facility would be minimized with water spray, water mists, dust-suppressant sprays, humidity control, directed airflow, and filtration. In addition, the retrieval equipment would be operated in **a** manner to minimize dust generation. All of the retrieval alternative evaluations included the following assumptions:

- Large objects will be handled on **a** case-by-case basis and **may** be left in **place** if **the** retrieval system cannot **safely handle** them
- Inaccessible soil beneath **large** objects will remain in the pit without treatment
- **Any** non-TRU **waste** with **dose** rates exceeding the facility design basis will be left in the pit.
- The excavated pit will be filled **as** shown in Figure 12

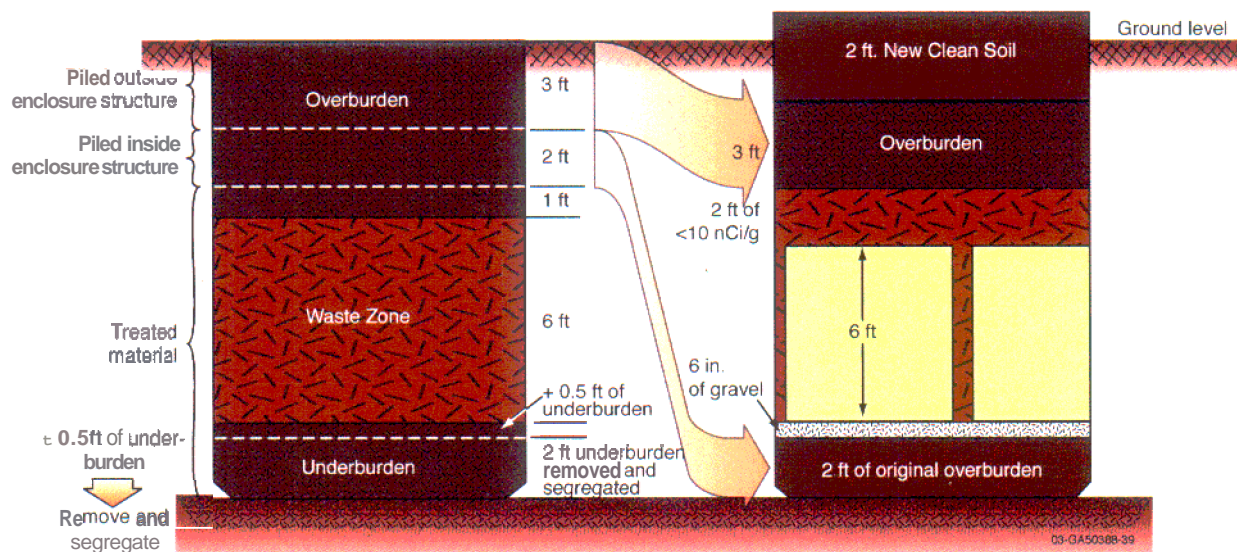


Figure 12. Cross-sectional view of the excavation site, both before and after retrieval.

Retrieval alternatives were developed after considering retrieval and disposition activities performed in the DOE complex and in the commercial and international sectors dating back to 1972. *Operable Unit 7-13/14 Evaluation of Soil and Buried Transuranic Waste Retrieval Technologies* (INEEL 2001) provides a summary of these retrieval and disposal activities. All of the prior retrievals researched were small-scale efforts, but they provide insight and lessons learned that are incorporated into the three Pit 9 retrieval alternatives evaluated.

All of the retrieval alternatives evaluated included excavating 28,000 yd³ of material from Pit 9 and returning treated non-TRU material to the pit.

4.1.2 Confinement Structure Alternative

The retrieval team evaluated movable buildings (EDF-4025 and INEEL 2003d) to retrieve 1/2-acre or larger portions of the pit, but established that the following complications would not allow retrieval operations to achieve the needed retrieval rates at an affordable cost:

- Increased complexity of building system designs
- Decontamination preceding each move
- Confirmation of enclosure seal integrity before recommencing retrieval operations
- Potential damage to structure and ancillary equipment with each move
- Size limitations placed on equipment selection.

Two other alternatives were evaluated. One was a large confinement building with separate cells to minimize contamination and allow for simultaneous retrieval and backfilling processes, but the moveable walls or curtains forming the separate cells presented concerns about the ability to seal edges, adequacy of walls or curtains as confinement boundaries, size limitations on retrieval equipment, and potential need to disassemble the walls when large objects are left in place. The other was a ground-level structure with all excavation processes performed below grade. This alternative was eliminated because of technical complexity, equipment access, and safety concerns.

A large, single-frame structure was selected to support primary and, if required, secondary confinement (refer to Figure 5). This structure, which covers the entire Pit 9 site, was preferred because is suitable for all three retrieval equipment methods evaluated and provides the following advantages:

- Seals more easily around the perimeter
- Can be built using standard construction materials and methods
- Accommodates a larger number of standard-sized retrieval equipment options
- Allows for retrieval rates to meet the enforceable deadlines for Pit 9.

Although the facility will not be assigned a preliminary hazard category until the conceptual design phase, it is anticipated that the facility will be a Hazard Category II nuclear facility. Based on similar projects, such as the OU 7-10 Glovebox Excavator Method Project, the use of a primary confinement with either a weather enclosure or secondary confinement structure is likely to be required.

4.1.3 Excavation Equipment Alternatives

The excavation equipment alternatives evaluated both above-grade equipment located on overburden with waste brought up from the dig face, and below-grade equipment located on the floor of the pit. Most mining equipment such as draglines and rotating earth cutters were eliminated because of their size and high production rates coupled with the potential for generating excessive dust. For all alternatives, excavation equipment is operated remotely and no personnel are within the enclosure, which minimizes the possibility of worker exposure. Redundant design is used for critical or high-wear equipment to minimize personnel entries into the enclosure for equipment maintenance.

After evaluating commercially available and applicable excavation equipment, the following three excavation equipment methods (see Table 1) were selected for further evaluation and analysis (INEEL 2003a).

- Backhoe-crane method (Alternative 1)
- Front-end loader-backhoe method (Alternative 2)
- Backhoe-forklift method (Alternative 3).

Backhoe-Crane Method (Alternative 1)

This alternative uses a remotely operated backhoe, bridge crane, and automatic guided vehicle (AGV). The backhoe loads material into boxes, the bridge crane with an attached box handler lifts the material and moves it to the end of the enclosure, and the AGV moves the material to its destination (see Figure 13). Return waste boxes from treatment are transported by the AGV and placed in the pit by the crane. Cover soil and clean overburden are compacted over the waste boxes to final grade.

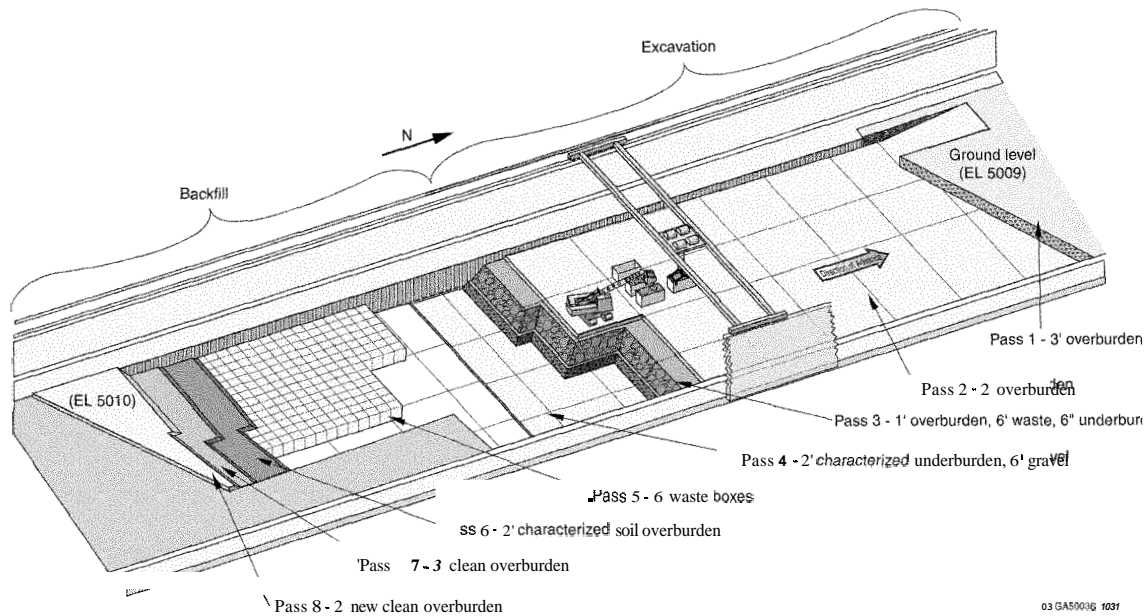


Figure 13. Retrieval Alternative 1 uses a remotely operated crane, backhoe, and AGV.

The advantages of the backhoe-crane method are (a) less contamination spread and dust generation from excavation because equipment is not tracked across the contaminated pit floor, (b) the crane remote-control functions are simple, and (c) the crane facilitates waste transport and box placement.

The disadvantages are (a) the crane's less functional flexibility, (b) more waste-handling functions, (c) dust generation and waste mixing from box loading, and (d) increased confinement structure size, strength, and ventilation rate with more decontamination and disassembly effort required.

Front-end loader-backhoe method (Alternative 2)

This alternative uses a remotely operated front-end loader and backhoe (see Figure 14). The front-end loader loads overburden material and delivers it to an outside clean overburden pile, the backhoe digs and piles the next 2 ft of overburden, and the front-end loader moves it to the inside pile for slightly contaminated soil.

Once the overburden is moved, the front-end loader excavates an access ramp through the existing soil to the base of the waste material zone, then digs and hauls the waste material and 6 in. of underburden material to the sorting deck, where it is emptied, sorted, and sent to characterization. While the front-end loader is removing waste, the backhoe, which is sitting on top of the 1-ft thick overburden, excavates the 1-ft thick overburden and piles it on the exposed underburden. The loader scoops up the piled overburden and delivers it directly to the sorting deck where contents are emptied, sorted, and sent to characterization. As the excavation advances, gravel is spread on the pit floor to harden the surface for wheel traffic. The backhoe moves to the pit floor on a soil ramp. It is then used to excavate the remaining 2 ft of underburden. The front-end loader transports it to the sorting deck for sorting and subsequent characterization. Return waste boxes from treatment are transported by the front-end loader with forklift attachment and placed in the pit. Cover soil and clean overburden are compacted over the waste boxes to final grade.

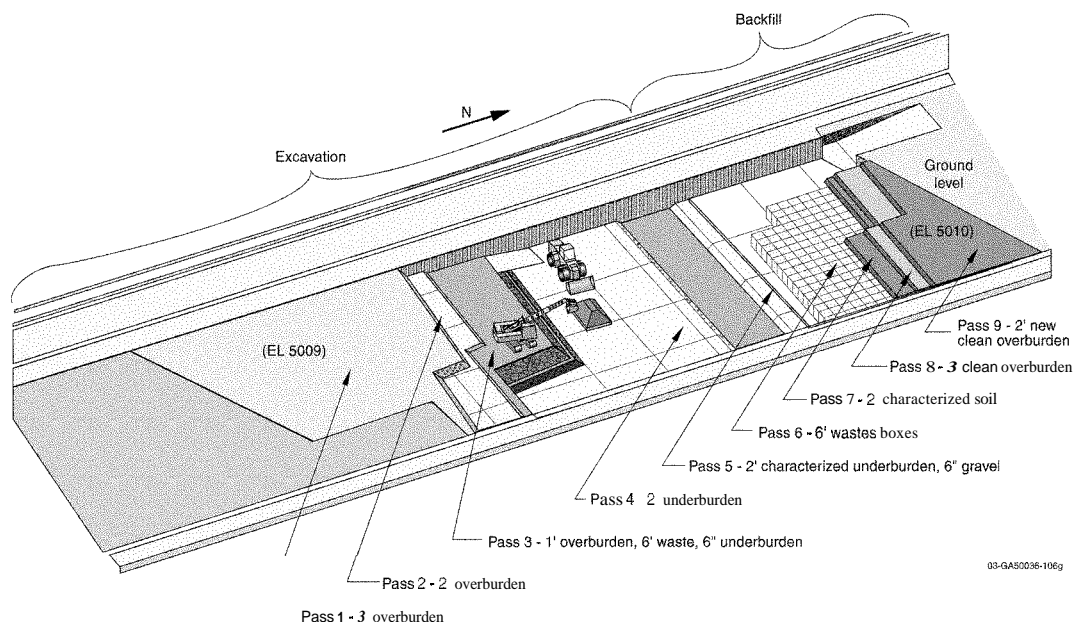


Figure 14. Retrieval Alternative 2 uses a remotely operated front-end loader and backhoe.

The advantages of the front-end loader–backhoe method include (a) maximum operational flexibility with the minimum set of complimenting remotely operated equipment; (b) variable excavation rates and ready handling of large and high-radiation objects; (c) the minimized size, strength, ventilation, and complexity of the confinement structure; and (d) a minimized confinement decontamination and disassembly effort in that all the equipment can be decontaminated and transported to other pit areas.

The disadvantages are (a) more sophisticated controls and software to safely operate unrestrained remote controlled equipment together in close proximity, and (b) tracking excavation equipment on the contaminated pit floor with its associated potential for contamination spread and dust generation.

Backhoe and Forklift Method (Alternative 3)

This alternative uses a remotely operated backhoe to excavate material as in Alternative 1, but instead of using a bridge crane to move the material, a remotely operated forklift moves the material to an AGV that transports the material to its destination (see Figure 15). The process is reversed for backfilling operations.

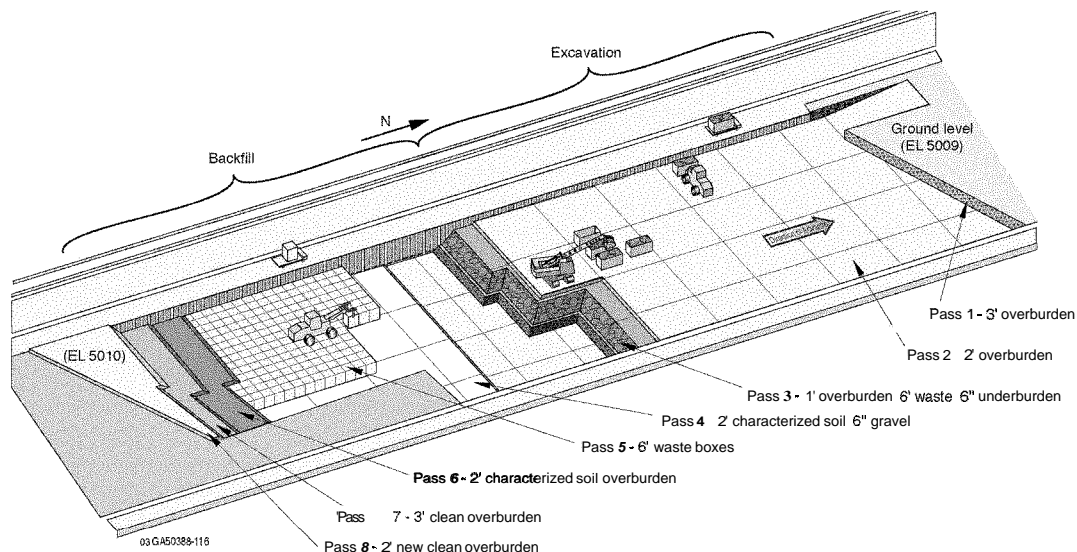


Figure 15. Retrieval Alternative 3 uses a remotely operated backhoe, forklift, and AGV

The advantages of the backhoe-forklift method are (a) minimized size, strength, ventilation, and complexity of the confinement structure; (b) minimized decontamination and disassembly effort; (c) excavation equipment can be decontaminated and transported to other areas of pit remediation; and (d) no tracking of equipment across the contaminated pit floor. These advantages resulted from using a forklift instead of a crane.

The disadvantages are (a) the required sophistication of controls, (b) greater diversity in types of remote equipment, (c) high-risk remote operations (driving on waste boxes), and (d) decreased large-object-handling capability.

4.1.4 Alternatives Analysis

Final analysis of the retrieval alternatives considered the technical performance, costs, schedule, and risks associated with each alternative. Based on these analyses, Alternative 2 (front-end loader–backhoe method) has the highest technical performance rating and the lowest capital and life-cycle cost, and takes the shortest time to construct. Alternative 2 has a higher unmitigated technical and safety risk than Alternative 1, but the differences are slight, and the present design concept mitigates the risks. Consequently, the front-end loader–backhoe method is the recommended retrieval alternative for conceptual design for the Pit 9 Remediation Project.

Technical Performance

A group of five project leads for the Pit 9 Remediation Project met to discuss, identify, and weigh decision criteria for the retrieval alternatives. Twenty-four draft criteria within five top-level headings were presented and discussed by the group. The draft criteria were based on the following CERCLA closure criteria:

- Long-term effectiveness and reduction of toxicity, mobility, and volume, which includes:
 - Volume of irretrievable waste left in the pit
 - Contamination spread to clean overburden
 - Contamination spread within waste
 - Volume of secondary waste generated
 - Contamination levels of secondary waste
 - Contamination spread to clean underburden
- Short-term protection of human health and environment, which includes:
 - Protection from plutonium uptake
 - Protection from radiation exposure
 - Protection from hazardous chemical exposure
 - Protection from industrial hazards
- Technical feasibility, which includes:
 - Designability
 - Constructability
 - Operability
 - Reliability
 - Flexibility
 - Maintainability
 - Inspectability
 - Operation risk (cost)
 - Decontaminability
 - Transferability to other pits and trenches.

A second meeting was held to evaluate the three alternatives against the criteria listed above. The evaluation team included both Pit 9 and non-Pit 9 engineers. Figure 16 summarizes the scoring of each alternative within the three main criteria groupings. Based on the distribution of the group's scores, Alternative 2, which rated particularly high in technical feasibility, was selected as the best overall alternative for retrieving waste from Pit 9.

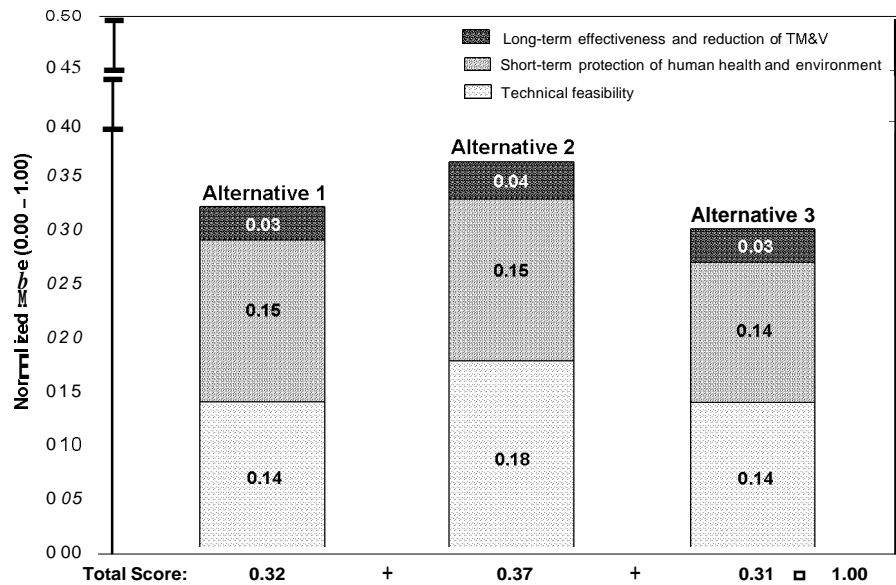


Figure 16. Summary scoring for each alternative within the three main criteria groups.

cost

Life-cycle costs shown as the total in Table 4, were developed for each of the three alternatives

Table 4. Life-cycle cost by alternative.

	Alternative 1 (\$K)	Alternative 2 (\$K)	Alternative 3 (\$K)
Capital	291,700	268,600	271,300
Operations, maintenance and consumable materials	192,600	171,500	173,500
Post-operations (DD&D)	35,300	32,400	28,200
Total (including escalation and contingency)	519,600	472,500	473,000
Discounted total*	406,700	369,900	371,000

* The life-cycle costs are discounted, or “brought back” to the present using the discounting rates provided in the Office of Management and Budget Circular A-94, “Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs” (OM 1994).

Schedule

Several enforceable deadlines were established in the ARD for the Pit 9 interim remedial action (refer to Table 3). This section presents the preliminary schedules for the three retrieval alternatives and discusses how they meet those enforceable deadlines. The schedules have been developed assuming that the project follows the process of review and approval at CD points as directed by DOE Order 413.3, where possible. The construction schedule estimates are based on planning level designs and have not been optimized. As the designs develop, constructability reviews will be held to ensure that features to speed construction are incorporated in the design where feasible. The schedules were prepared to compare the three different retrieval alternatives, and therefore do not represent final schedule estimates. In all cases, current planning site preparation work such as clearing and grading, utility work, and installation of sheet piling is not considered to be the start of construction, triggering the 36 month enforceable deadline.

In comparing the schedules, all three alternatives complete construction within 2 months of each other. However, because of the size of the retrieval facilities, construction must be phased and completed before the 3-year period allowed by the ARD and before completion of the final design phase and submittal of the 90% design to NE-ID, the EPA, and IDEQ). Early construction work will include site preparation, utilities, sheet piling, and foundation installation followed by the structural, mechanical, and electrical installations.

Retrieval operations for all three alternatives complete within three years. The first 6 months of operations will be dedicated to overburden removal and then 18 months will be required for waste retrieval and the final 12 months for waste return to the pit for final disposition. The schedule for Alternative 2 is provided in Figure 17. A separate schedule was not developed for the other alternatives because the schedule difference is minimal.

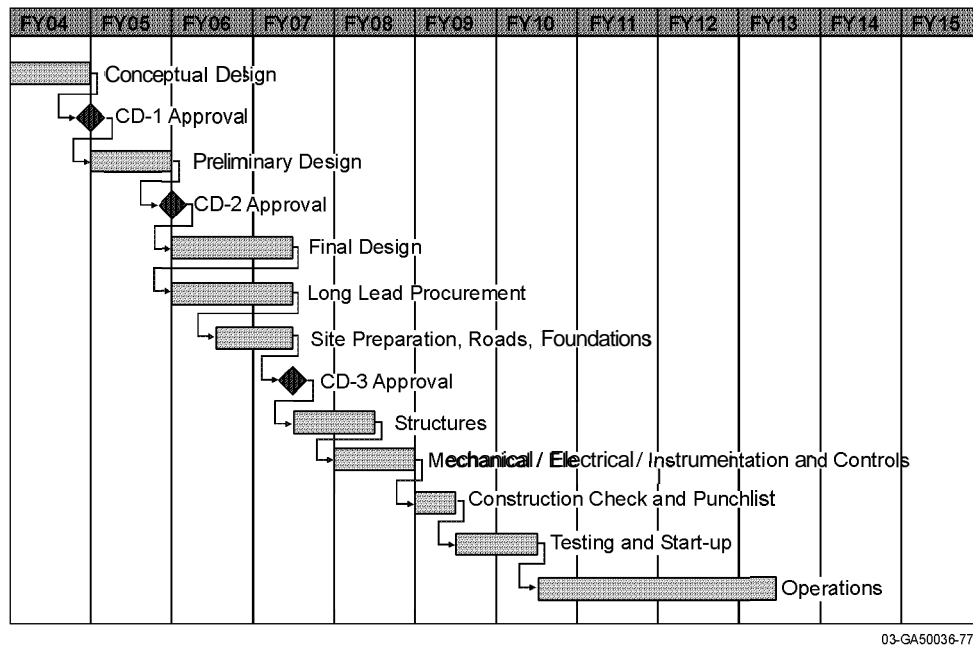


Figure 17. Retrieval schedule for Alternative 2.

Risk

A preliminary risk assessment of technical and safety risks was conducted on each of the alternatives as part of the preconceptual design. Major risks were initially identified in a risk statement generated by the project team. The technical and safety risks were then separated from the general project risks and assigned a qualitative value for probability of occurrence and consequence of occurrence. The combination of probability and consequence values resulted in a qualitative risk factor. Quantitative values were assigned to the probabilities and consequences to evaluate the differences in the initial risk factors for the alternatives. The values for probability and consequence range from 0 to 1. The initial risk factor sum for each alternative comes from multiplying the values for probability and consequence to obtain an initial risk factor value for each risk, and then adding all the initial risk values. The sums of initial risk factors for each alternative are as follows:

- Alternative 1 – 3.20
- Alternative 2 – 3.64
- Alternative 3 – 3.64

Initial handling strategies were also developed for each risk. The handling strategies mitigate the risk either by lowering or eliminating its probability or decreasing the consequence. The initial risk factors calculated do not include mitigation of the risk by incorporation of the handling strategies in the design; however, the current design concepts include features that mitigate the major safety risks.

4.2 Treatment

The treatment portion of the Pit 9 remediation includes the following functions:

- Assay of the retrieved material to determine if it is TRU (contaminated with TRU nuclides at levels greater than 100 nCi/g) or non-TRU (less than or equal to 100 nCi/g)
- Treatment, packaging, storage, and preparation for shipment to WIPP of the TRU fraction
- Treatment, as necessary, of the non-TRU fraction and return of the non-TRU material to the pit.

The degree to which TRU material is treated can range from a minimum of characterization and packaging to meet the WIPP waste acceptance criteria, to a maximum of volume reduction and immobilization before characterization and packaging. The treatment study developed three TRU alternatives from an initial set of 14 (see Figure 18) that spanned this range of treatment to provide data on cost, schedule, and technical feasibility to support discussions with the EPA and IDEQ in selecting the degree of treatment to pursue.

The treatment of non-TRU material focuses on treating the primary nonradiological contaminants of concern and VOCs, which are predominantly halogenated hydrocarbons such as carbon tetrachloride and 1,1,1 trichloroethane. Three treatment alternatives were identified and two were selected for further development (see Figure 18).

The following sections describe the alternatives that were carried forward, provide a summary cost and schedule data for each, and give an assessment of all of the alternatives.

4.2.1 Treatment Technology Selection Process

An initial set of treatment scenarios was developed by a group of chemical and mechanical engineers with experience in DOE complexwide technology development and evaluation, design and construction of treatment facilities for radioactive and hazardous waste, and the applicable regulatory frameworks. These engineers identified a total of 14 process concepts for treating the TRU portion of the retrieved material in a brainstorming session that considered a broad range of demonstrated treatment technologies including compaction, decontamination, incineration, melting, chemical oxidation, supercritical water oxidation, and chemical leach. These alternatives were collected in the following five general categories:

- The first category called for compaction of the waste.
- The second category involved thermal treatment of all the waste to effect an overall volume reduction of the TRU fraction. Alternative 2a considered incineration (or other thermal treatment of the shredded waste and soil) to achieve an additional volume while Alternative 2b considered a melting process in which both the waste and the soil are reduced to slag. However, these categories did little to reduce the volume of TRU soil.
- The third category evaluated treatment of the soil to remove the TRU contamination. This soil treatment was considered to be some type of chemical leach process. Alternatives 3a and 3b considered removal of the organic contamination from the soil by thermal desorption or solvent extraction (respectively) followed by chemical leach of the soil. In either case, the debris was segregated from the soil, shredded, and compacted.
- The fourth category improved the volume reduction by chemically treating the soil, as in Category 3 and thermally treating the debris. This thermal treatment system was also used to treat the concentrate from the leach process. A total of four alternatives were considered, combining solvent extraction or thermal desorption with incineration or melting.
- The fifth category considered leaching of the soil and decontamination of the debris. A total of five alternatives were considered in this category.

Preliminary block flow diagrams and material balances were developed for these 14 concepts and they were evaluated on technical complexity and feasibility, volume reduction, and volume of secondary waste. These mass balances clearly indicated that, in terms of the volume of materials sent to WIPP or returned to the pit, there were three distinct classes. Alternative 1, compaction, was the baseline against which the rest were compared. The second category, thermal treatment, provided a better TRU volume

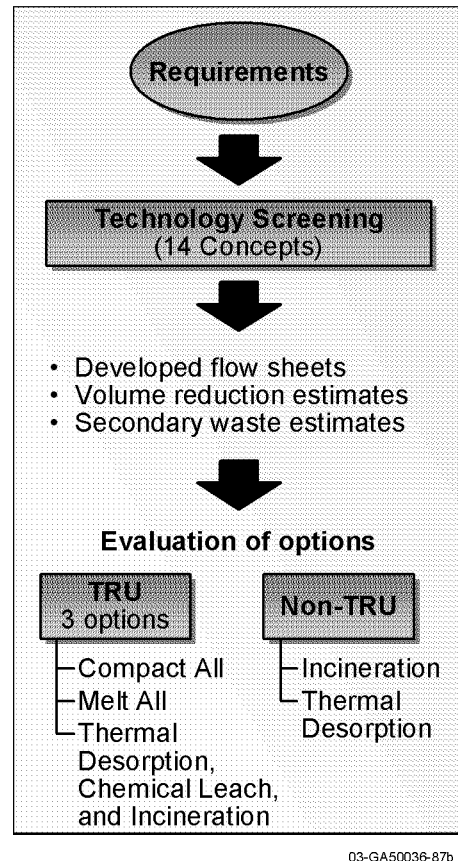


Figure 18. Treatment alternative selection process.

reduction than Alternative 1 without a significant penalty in secondary waste generation and was retained for further analysis. Category 3 provided a volume reduction of the TRU material similar to that of Category 2, but had a substantially larger secondary waste volume and was therefore eliminated. Category 4 clearly had the highest volume reduction of the TRU material and was retained for that reason. Category 5 was also discarded because it provided only moderate TRU material volume reduction with high secondary waste production. A summary of the results of these preliminary mass balances is shown in Table 5. Alternative 5e, which employed bioremediation of the organic waste was eliminated on the basis of feasibility; therefore, no mass balances were generated for that alternative. Additional information regarding the initial concepts and the selection process is available in EDF-3634, "Treatment Technology Screening for OU 7-10 Stage III Project."

Three alternatives that spanned the range of complexity and volume reduction were selected from these 14 for more detailed analysis. The technologies employed in these alternatives were simple compaction, a more technically complex alternative that melted all the TRU in an electric melter, and the most complicated approach, which included thermal desorption of organics, chemical leach of the contaminated soil, and incineration of the TRU debris.

Three non-TRU treatment alternatives were also identified as part of this process, which, after evaluation, were reduced to two: thermal desorption (Alternative 3aP) and incineration (Alternative 2aP). These non-TRU alternatives spanned the range of performance and complexity and helped to establish technical performance, cost, schedule, and risk considerations used in the decision making process. Feasibility level designs were developed for each alternative to establish overall facility sizes and major equipment items for planning level cost estimates. Thermal desorption was selected as the non-TRU alternative as explained in Section 4.2.2.

The life-cycle cost estimates were complicated by two factors that could not be firmly established at this time: (1) the total volume of waste to be retrieved, and (2) the costs to be assigned to the disposal of TRU waste at WIPP. The Pit 9 Remediation Project is intended to be flexible enough to apply to other TRU pits and trenches in the SDA, but it is not certain how many of these sites will have to be remediated. Recent court rulings, currently being appealed by DOE, indicate that previous agreements about removal of TRU from Idaho are interpreted to apply to all of the stored and buried TRU. Therefore, there may be some impetus for retrieval of more of the buried TRU than previously thought. As a basis of comparison, the life-cycle costs were developed for three remediation scenarios:

- A 1-acre retrieval, representing Pit 9 or a similar pit for demonstration
- An intermediate 4-acre retrieval (consistent with the Life Cycle Baseline)
- An 8-acre retrieval, which is expected to result in removal of a significant portion of the TRU in the SDA.

The operating and disposal costs for the larger remediation areas were assumed to be proportional to the areas to be remediated. It should also be noted that the volume of waste removed from the SDA in these scenarios (especially the 8-acre scenario) is significant when compared to the remaining capacity and actual disposal cost at WIPP; thus, the WIPP issues must also be considered when selecting the final treatment technology. Therefore, two treatment alternative life-cycle cost estimates were developed with different WIPP disposal costs, one with the lower transportation and disposal costs, and the other, with what is considered the actual WIPP life-cycle cost.

Table 5. Disposal volumes and volume reduction for treatment alternatives.

The total volume of material removed from Pit 9 is assumed to be 350,000 ft³ (9,920 m³) of soil and 150,000 ft³ (4,250 m³) of waste.

Alternative	Treated Waste Shipped to WIPP ^a (m ³)	% Volume Reduction to WIPP ^b	Total Volume Returned to Pit 9 ^c (m ³)	Ratio of volume returned to total Excavated ^d	Volume of Secondary Waste to Offsite Treatment ^e (m ³)	Process
4b	561	92%	21,469	1 54	0	Segregate debris, thermally desorb and leach soil, shred and melt debris and condensed organics
4d	561	92%	21,469	1 54	0	Segregate debris, solvent extract and leach soil, shred and melt debris and condensed organics
4a	746	89%	21,469	1 54	0	Segregate debris, thermally desorb and leach soil, shred and thermally treat debris and condensed organics
4c	746	89%	21,469	1 54	0	Segregate debris, solvent extract and leach soil, shred and thermally treat debris and condensed organics
2b	3,387	51%	9,818	0 71	0	Shred and melt all waste
5a	3,397	51%	21,092	1 52	122	Segregate debris, thermally desorb and leach soil, shred and decon debris, treat condensed organics offsite
5b	3,397	51%	21,468	1 54	0	Segregate debris, thermally desorb and leach soil, shred and decon debris, thermally treat condensed organics onsite
5c	3,397	51%	21,481	1 54	0	Segregate debris, thermally desorb and leach soil, shred and decon debris, SCWO condensed organics onsite
5d	3,397	51%	21,481	1 54	0	Segregate debris, thermally desorb and leach soil, shred and decon debris, ChemOx condensed organics onsite
3a	3,693	47%	21,092	1 52	122	Segregate debris, thermally desorb and leach soil, shred and compact debris, condense and treat organics offsite
3b	3,693	47%	21,092	1 52	122	Segregate debris, solvent extract and leach soil, shred and compact debris, condense and treat organics offsite
2a	5,406	22%	9,818	0 71	0	Shred and thermally treat all waste
1	6,859	1%	9,440	0 68	0	Compact everything

a. Total volume of 6,957 m³ treated waste that is shipped to WIPP following treatment

b. Ratio of the volume sent to WIPP to the total volume >100 nCi/g excavated from Pit 9.

c. Total volume of waste that is returned to the pit, including that which is assayed at <100 nCi/g.

d. Ratio of volume of waste returned to Pit 9 (including that which is <100 nCi/g) , to the total excavated waste.

e. Includes spent activated carbon and recovered volatile organics.

NOTE 1: Alternative 5e, which employed bioremediation of the organic waste, was eliminated based on nonfeasibility.

NOTE 2: The volume reduction numbers presented in this table were based on initial analyses; final numbers may differ slightly

The cost of transportation and disposal at WIPP can also be interpreted in several ways. It could mean simply the cost of operations associated with transportation and disposal of the waste containers below ground at WIPP. Or, it could consider the development, permitting, design, and other costs of building, operating, and closing WIPP in addition to the certification, transportation, and disposal costs, which comprehensively covers the total costs of TRU waste to DOE.

4.2.2 Alternatives Descriptions

The following sections provide descriptions of the combined TRU and non-TRU alternatives. Capital cost estimates were developed for two cases, the Compact All TRU alternative with the non-TRU-incineration alternative and the Compact All TRU alternative with the non-TRU thermal-desorption alternative. The costs for the non-TRU incineration case were much higher than the costs for the non-TRU thermal desorption case. Because there was no apparent advantage to volume reduction of the material being returned to the Pit, and noting that community resistance to incinerators has been very strong in the past, the non-TRU-incineration alternative was eliminated. Thus, the non-TRU thermal desorption alternative is combined with all the TRU alternatives discussed in this section.

Some of the functions provided in these alternatives are similar to those that will be provided as part of the AMWTP that recently completed construction at the RWMC. While these functions were included as stand-alone capabilities in Alternative 1, discussions have started with the AMWTP. The next phase of the project will more closely evaluate the potential for using these existing assets.

Compact All (Alternative 1)

In Alternative 1 (see Figure 19), retrieved material is segregated into waste and soil streams for assay and further treatment if necessary. Waste is shredded, packaged, and assayed. Containers that are contaminated with TRU at levels greater than 100 nCi/g are compacted, repackaged, and stored to meet drum-aging criteria for headspace sampling (a WIPP characterization requirement). Soil is assayed on a conveyor-based system and packaged. The containers with greater than 100 nCi/g TRU contamination are also stored to meet drum-aging criteria for headspace sampling. The soil containers are not compacted because the density of the soil is already quite high and the slight compaction that could be achieved would be offset by the subsequent repackaging so that no volume reduction would be achieved (a volume increase would be more likely). The TRU containers are certified for disposal at and shipped to WIPP. Non-TRU material must pass additional decision points before being returned to the pit. If containers are found to be contaminated with uranium or PCBs at levels greater than the corresponding action levels (which have not yet been established), they will be placed in storage until the level of contamination can be accurately determined and processes developed to deal with them. At that time, additional treatment operations will be added, if necessary. Uranium has also been identified as a contaminant of concern for the entire SDA. Containers from Pit 9 with high levels of uranium will be held for treatment in systems provided for the subsequent remediation efforts. Finally, non-TRU material that is not contaminated with PCBs or uranium but is contaminated with VOCs above action levels will be treated by low-temperature thermal desorption to remove the VOCs.

The schedule for this alternative meets all the schedule deadlines mandated in the 2002 ARD (see Figure 20). The 10% design, which is considered to be the same as the conceptual design, is actually submitted one year early. This early submittal date is needed to support the next deadline — start of construction by March 31, 2007.

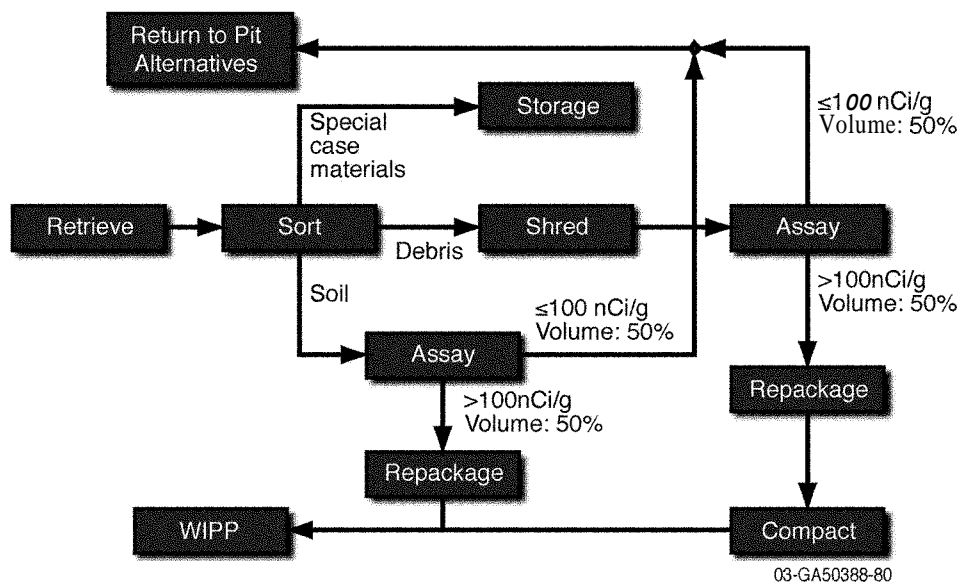


Figure 19. Block flow diagram for treatment Alternative 1.

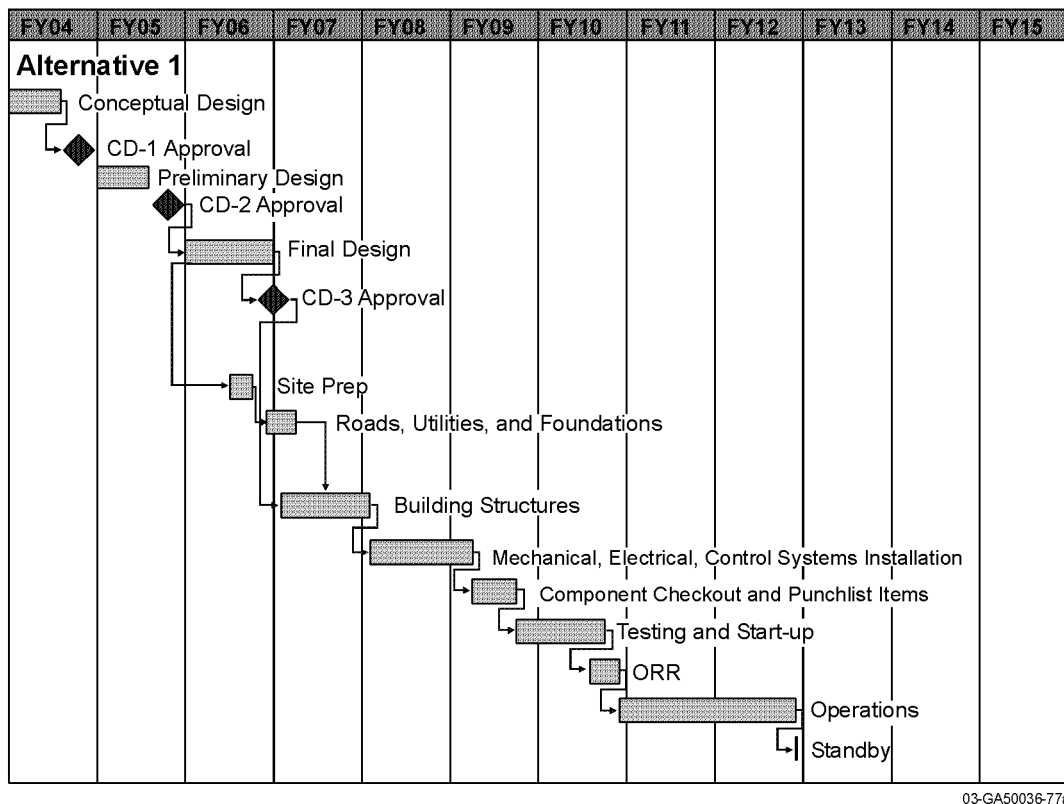


Figure 20. Schedule for treatment Alternative 1.

The construction schedule was based on planning level designs and has not been optimized. As the designs develop, constructability reviews will be held to assure that features to speed construction are incorporated into the design where feasible. The schedules presented in this section are intended to highlight the differences between the three treatment alternatives and do not represent final schedule estimates. This schedule, as currently envisioned, requires more than 36 months from the time the first efforts are started on the site until the system is ready for operation. For the purposes of the ARD deadlines, it is proposed that initial site preparation, utility work, and initial excavation not be considered to trigger the start of the construction deadline.

Again, these schedule estimates are not final, and will continue to be refined as the design progresses. The design and procurement activities will focus on minimizing the overall construction duration.

As noted above, life-cycle costs were developed for several combinations of WIPP disposal costs and volume of material retrieved to provide some insight into the importance of these parameters. The life-cycle costs for the various cases are shown in Tables 6, 7, and 8.

Table 6. Life-cycle costs for treatment Alternative 1 and 1-acre retrieval.

	High WIPP Cost (\$K)	Low WIPP Cost (\$K)
Capital	385,500	385,500
Operations	298,800	299,000
WIPP disposal	678,800	76,100
DD&D	79,700	79,700
Total (including escalation and contingency)	1,442,800	840,300
Discounted total	1,080,400	651,100

Table 7. Life-cycle costs for treatment Alternative 1 and 4-acre retrieval.

	High WIPP Cost (\$K)	Low WIPP Cost (\$K)
Capital	385,500	385,500
Operations	791,600	792,200
WIPP disposal	2,375,800	266,400
DD&D	91,500	91,500
Total (including escalation and contingency)	3,644,400	1,535,600
Discounted total	2,429,000	1,069,100

Table 8. Life-cycle costs for treatment Alternative 1 and 8-acre retrieval.

	High WIPP Cost (\$K)	Low WIPP Cost (\$K)
Capital	385,500	385,500
Operations	1,806,800	1,808,100
WIPP disposal	5,430,500	608,800
DD&D	114.100	114.100
Total (including escalation and contingency)	7,736,900	2,916,500
Discounted total	4,445,900	1,715,000

Melt All (Alternative 2b)

Alternative 2b (see Figure 21) employs a facility similar to the WRPf described in Alternative 1 to receive and characterize material retrieved from Pit 9. Rather than compacting the TRU waste and simply packaging the TRU soil, both TRU streams are sent to the Melter Treatment Facility for further treatment. The Melter Treatment Facility containing the electrical arc melter, off-gas treatment equipment, container filling and cooling systems, and container storage is located adjacent to the WRPf. In the Melter Treatment Facility, the waste and soil is fed to a high-temperature arc melter that reduces these streams to slag. This process produces an excellent waste form because it completely destroys the organic component of the waste, converts nitrates and other compounds to oxides, and results in an inert slag product. As a result, the volume of the waste is reduced and the headspace sampling of the containers can be performed on a statistical basis (rather than for all containers, as in Alternative 1). Although the overall volume of waste disposed at WIPP is reduced, the number of shipments to WIPP are almost the same as for Alternative 1. This is due to the high density of the slag product and the weight limitations of the TRUPACT-II transportation system.

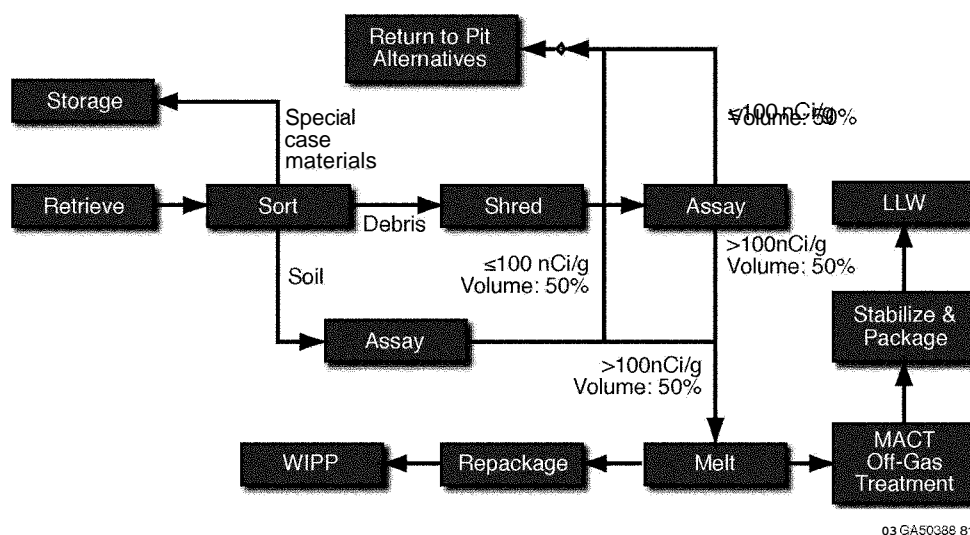


Figure 21. Block flow diagram for treatment Alternative 2b.

Off gas from the melter is routed through a secondary combustion chamber to assure that all gaseous products from the melter are completely oxidized. Downstream of the secondary combustion chamber are treatment subsystems for removing particulate, oxides of nitrogen, and other contaminants to comply with the applicable requirements of the hazardous waste combustors maximum achievable control technology standards (40 CFR 63 Subpart EEE, “National Emission Standards for Hazardous Air Pollutants from Hazardous Waste Combustors”). The system is also provided with HEPA filtration to assure that particulate radionuclide emissions are reduced to acceptable levels.

As in Alternative 1, the non-TRU material with high levels of uranium or PCBs are placed in storage. A non-TRU thermal desorption facility similar to that described for Alternative 1 is located adjacent to the WRPf where non-TRU material with VOC contamination is treated.

The schedule for this alternative (see Figure 22) meets the first two schedule deadlines mandated in the ARD—submittal of 10% design and commencement of construction. This schedule does not start operations until September 2011, 17 months after the ARD start of operations deadline.

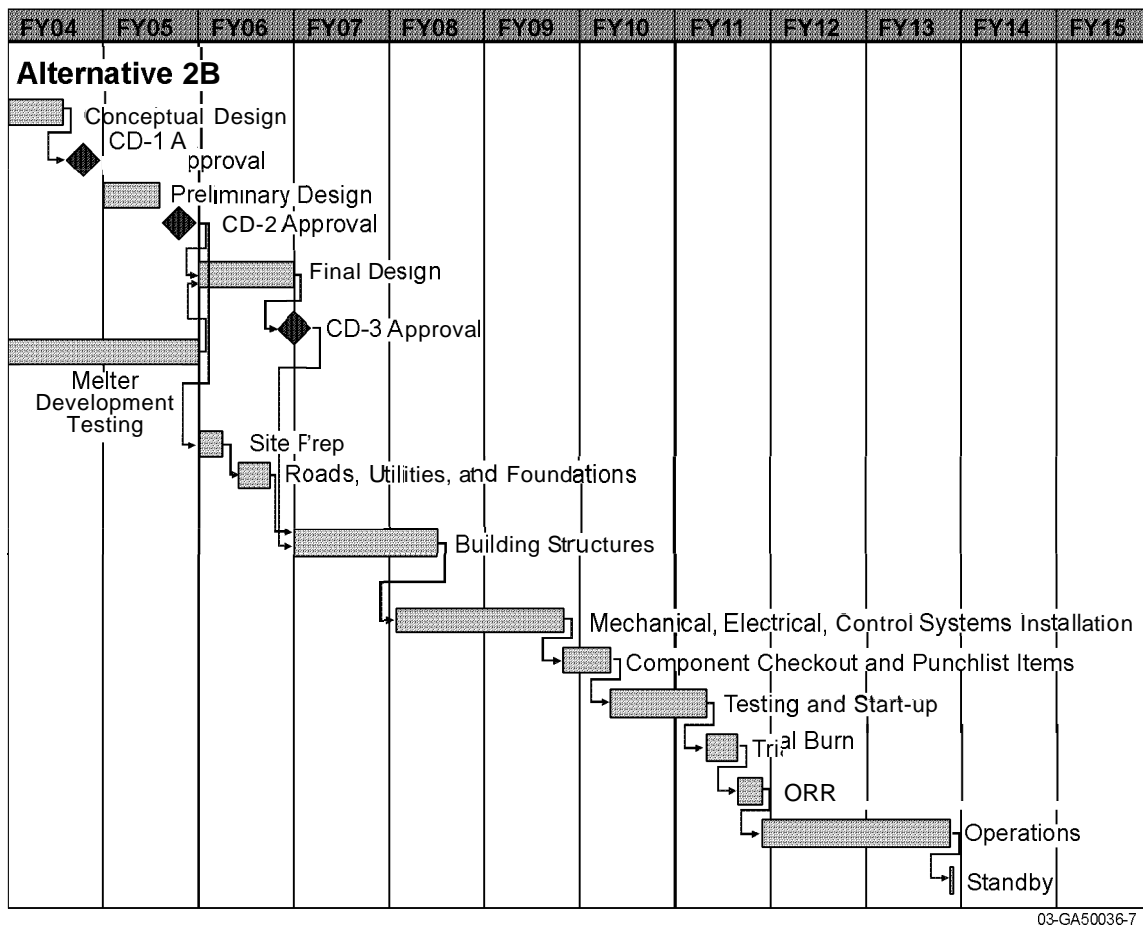


Figure 22. Schedule for treatment Alternative 2b.

The life-cycle costs for the various cases are shown in Tables 9, 10, and 11

Table 9. Life-cycle costs for treatment Alternative 2b and 1-acre retrieval.

	High WIPP Cost (\$K)	Low WIPP Cost (\$K)
Capital	463,500	463,500
Operations	466,900	467,000
WIPP disposal	319,900	35,900
DD&D	88.700	88.700
Total (including escalation and contingency)	1,339,000	1,055,000
Discounted total	987,200	739,100

Table 10. Life-cycle costs for treatment Alternative 2b and 4-acre retrieval

	High WIPP Cost (\$K)	Low WIPP Cost (\$K)
Capital	463,500	463,500
Operations	1,370,900	1,371,300
WIPP disposal	1,279,700	143,500
DD&D	104.600	104.600
Total (including escalation and contingency)	3,218,700	2,082,900
Discounted total	2,062,600	1,373,200

Table 11. Life-cycle costs for treatment Alternative 2b and 8-acre retrieval

	High WIPP Cost (\$K)	Low WIPP Cost (\$K)
Capital	463,500	463,500
Operations	2,834,800	2,835,400
WIPP disposal	2,559,300	286,900
DD&D	130.500	130.500
Total (including escalation and contingency)	5,988,100	3,716,300
Discounted total	3,249.200	2,063.800

Thermal Desorption, Chemical Leach, and Incineration (Alternative 4a)

Alternative 4a most closely matches the remedy described in the *Pit 9 Interim Action ROD* by incinerating the TRU debris and chemically treating the TRU soil to effect a volume reduction of about 90%, given the assumptions about the amount of TRU waste and soil. Note that these assumptions will be updated when the OU 7-10 Glovebox Excavator Method Project data are available, and this volume reduction may change. Although Alternative 4a provides the greatest volume reduction of the TRU material, it has the highest technical risk, highest capital cost, and longest schedule. A simplified block flow diagram is shown in Figure 23.

elements such as calcium to precipitate as oxalates. The solution is filtered and the sludge containing the TRU is stored to geometrically favorable tanks before being injected into the incinerator. The incineration process evaporates the water in the sludge and converts the oxalates to solid metal oxides, gaseous carbon dioxide, and water. The treated soil and liquid from the precipitation process are dried to remove the majority of the water and calcined to decompose the nitrates to nitrogen oxides (NO_x). This calcining process is necessary to reduce the mass of material, particularly the mass of nitrates, being returned to the pit. The dried treated soil is packaged for return to the pit, assayed to confirm that TRU contamination levels are less than or equal to 100 nCi/g, and returned to the pit. The NO_x stream from the calciner is treated in a two-stage combustion process to reduce it to nitrogen gas, water, and carbon dioxide.

The material that is not contaminated with TRU at greater than 100 nCi/g is evaluated for uranium, PCB, and VOC contamination, and managed accordingly. The noncontaminated material and treated non-TRU material will be returned to the pit.

The schedule for this alternative (see Figure 24) meets the 10% design deadline mandated in the ARD. The 10% design is submitted in 2005 rather than 2004 as in the other alternatives. This is because the design effort is delayed 1 year while technology development efforts are conducted. Due to this delay, construction and operations mandated deadlines are not met.

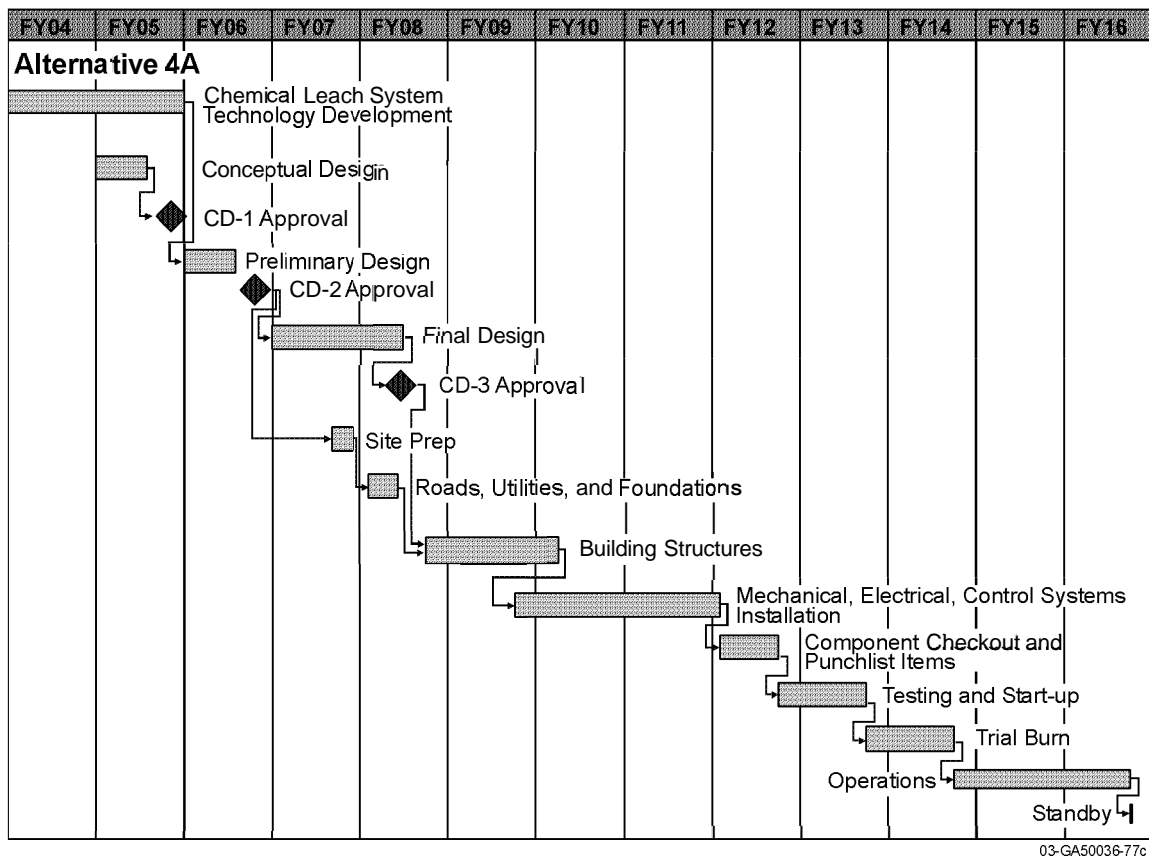


Figure 24. Schedule for treatment Alternative 4a

The life-cycle costs for the various cases are shown in Tables 12, 13, and 14

Table 12. Life-cycle costs for treatment Alternative 4a and 1-acre retrieval.

	High WIPP Cost (\$K)	Low WIPP Cost (\$K)
Capital	555,500	555,500
Operations	517,500	517,500
WIPP disposal	64,600	7,200
DD&D	99,200	99,200
Total (including escalation and contingency)	1,236,800	1,179,400
Discounted total	863,800	828,800

Table 13. Life-cycle costs for treatment Alternative 4a and 4-acre retrieval.

	High Waste Isolation Pilot Plant Cost (\$K)	Low Waste Isolation Pilot Plant Cost (\$K)
Capital	555,500	555,500
Operations	1,622,500	1,622,600
WIPP disposal	258,500	29,000
DD&D	118,000	118,000
Total (including escalation and contingency)	2,554,500	2,325,100
Discounted total	1,531,400	1,407,000

Table 14. Life-cycle costs for treatment Alternative 4a and 8-acre retrieval

	High Waste Isolation Pilot Plant Cost (\$K)	Low Waste Isolation Pilot Plant Cost (\$K)
Capital	555,500	555,500
Operations	3,285,900	3,286,000
WIPP disposal	484,600	54,300
DD&D	146,100	146,100
Total (including escalation and contingency)	4,472,100	4,041,900
Discounted total	2,308,700	2,104,500

4.2.3 Alternatives Analysis

The CERCLA process identifies the following nine criteria for evaluating alternatives (42 USC § 9601 et seq., 1980). While this evaluation is not intended to replace the evaluation conducted as part of the *Pit 9 Interim Action ROD*, these criteria are certainly reasonable ones to apply.

Threshold Criteria

1. Overall protection of human health and the environment
2. Compliance with applicable or relevant and appropriate requirements

Balancing Criteria

3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost (and supporting schedule)

Modifying Criteria

8. State acceptance
9. Community acceptance.

Threshold Criteria

All three alternatives are considered to meet the threshold criteria (protection of human health and the environment and compliance with applicable or relevant and appropriate requirements). This criterion is not considered a discriminator.

Balancing Criteria

The evaluation of the three TRU alternatives against the balancing criteria is provided below.

Long-term Effectiveness and Permanence — With respect to the TRU hazard, all three alternatives are deemed equal because all remove the same amount of TRU from Pit 9 and dispose of that material in WIPP. With respect to other hazardous constituents, the disposal of this material in WIPP should provide satisfactory (and equal) long-term isolation from the environment. Similarly, all three alternatives perform equally, in that they treat the non-TRU material that is contaminated with VOCs to required land disposal restrictions, and store any PCB or uranium contaminated material for later treatment.

Reduction of Toxicity, Mobility, or Volume through Treatment — The three alternatives vary in the reduction of toxicity, mobility, or volume (TMV) of the TRU waste. Treatment Alternative 1 provides minimal reduction in TMV. The best immobilization and reduction of toxicity is achieved with Alternative 2b, which either destroys the contaminants due to the high temperatures (e.g., the VOCs) or ties them up in the slag from the melter. Various studies have shown that this slag provides very good immobilization. The best volume reduction of the TRU waste is achieved in Alternative 4a.

This criterion should, however, be considered in the context of the WIPP disposal site, which has been designated as the national geologic repository for defense generated TRU waste. Its performance assessment indicates that it is protective of human health and the environment, regardless of its form. Hence, CERCLA requirements for reduction in toxicity and mobility may be less important in this case.

The reduction of volume is potentially important to WIPP. The current WIPP capacity of 175,600m³ for both contact-handled TRU waste and remote-handled TRU waste was set by the WIPP Land Withdrawal Act (Public Law 102-579), signed in 1992. Subtracting the 7,080 m³ allowed for remote-handled TRU, the contact-handled capacity is 168,520m³. According to the National TRU Waste Management Plan, the total contact-handled volume to be disposed is 113,300m³. This leaves 55,200m³ for disposal of additional wastes that are not included in the plan but could (or will) be generated at various sites across the country. The selection of the treatment alternative, especially if more than one acre is to be remediated, can significantly impact the remaining WIPP capacity.

Table 15 summarizes the performance of the three alternatives with respect to the volume reduction of the waste for the 1-acre retrieval. Alternative 1 provides no volume reduction (actually a slight volume increase). Generally, a compaction technology would be expected to provide some volume reduction but this waste stream is not typical of most TRU waste streams evaluated in the past. The single largest factor is that nearly 70% by volume of the TRU material is soil and the compaction that can be achieved with soil is minimal. Alternative 1, even for the 1-acre retrieval, uses 13% of the remaining WIPP capacity. If the results are extrapolated to an 8-acre retrieval, the waste volume exceeds the WIPP capacity. The best volume reduction of the TRU fraction of the retrieved material is achieved in Alternative 4a, which, even under the 8-acre scenario, only requires about 7% of the remaining WIPP capacity. It is important to note that other sites may, or more probably will, have additional demands for disposal capacity so volume reduction capability becomes even more important. Finally, it is important to note that these volume reduction percentages are based on the assumption that 50% of the waste and 50% of the soil is TRU. Data from the OU 7-10 Glovebox Excavator Method Project are expected early in Calendar Year 2004 and these data may change the assumptions about the volumes of TRU waste and soil that will be retrieved from the rest of Pit 9. Changing these assumptions could significantly affect these volume reduction percentages.

Table 15. Volume reduction capabilities of treatment alternatives.

Total Volume of Waste Removed from Pit 9: 14,000 m ³					
Total Initial Volume Transuranic Waste: 7,000 m ³					
	Ship to WIPP (m ³)	% Volume Reduction to WIPP	Return to Pit 9 (m ³)	Pit 9 Return Ratio	Secondary Waste to Off-Site Treatment (m ³)
Alt 1 (Compact All) + Alt 3aP (Thermal Desorption and Return to Pit)	7,500	-7%	6,300	0.5	300
Alt 2b (Melt All) + Alt 3aP (Thermal Desorption and Return to Pit)	3,500	50%	6,500	0.5	300
Alt 4a (Thermal Desorption, Chemical Leach, and Incineration) + Alt 3aP (Thermal Desorption and Return to Pit)	500	93%	13,600	1.0	300

WIPP = Waste Isolation Pilot Plant

Short-term Effectiveness—The protection of human health and the environment during construction and implementation of all three alternatives are considered essentially equal. The high temperatures of Alternative 2b and the high temperatures and chemical hazards of Alternative 4a potentially pose higher risks to human health and the environment during construction and implementation than that of Alternative 1.

Implementability—There are distinct differences in the technical and administrative feasibility of these three alternatives. Alternative 1 is similar to the AMWTP, which has recently completed construction and it is rated highest in this category. Alternative 2b is rated the next highest. Facilities that melt waste using electric arc, plasma arc, or similar technologies have been built in various locations around the world, but none have been demonstrated on the types of waste expected from Pit 9. Alternative 4a is rated lowest. From a technical perspective, the chemical leach process requires additional research to verify the performance of the process and establish certain design parameters such as the ultimate TRU dissolution effectiveness, the filtration efficiency in separating the dissolved TRU from the remaining soil, and final volume reduction. Prototype testing is needed to confirm equipment selection and design concepts for critical components such as filters, pumps, and the calciner. The overall concept—thermal desorption, chemical leach, and incineration—is complex, and presents its own set of complications, even in a technically mature process. These complications will also result in operational complexities in start-up, system integration, and day-to-day operations.

Cost (and supporting schedule)—The life-cycle costs presented for the various alternatives show that the volume of material to be retrieved and the cost assigned for transportation to and disposal at WIPP will drastically affect the results. The non-discounted life-cycle costs for the various retrieval volumes and disposal costs are summarized in Figure 25.

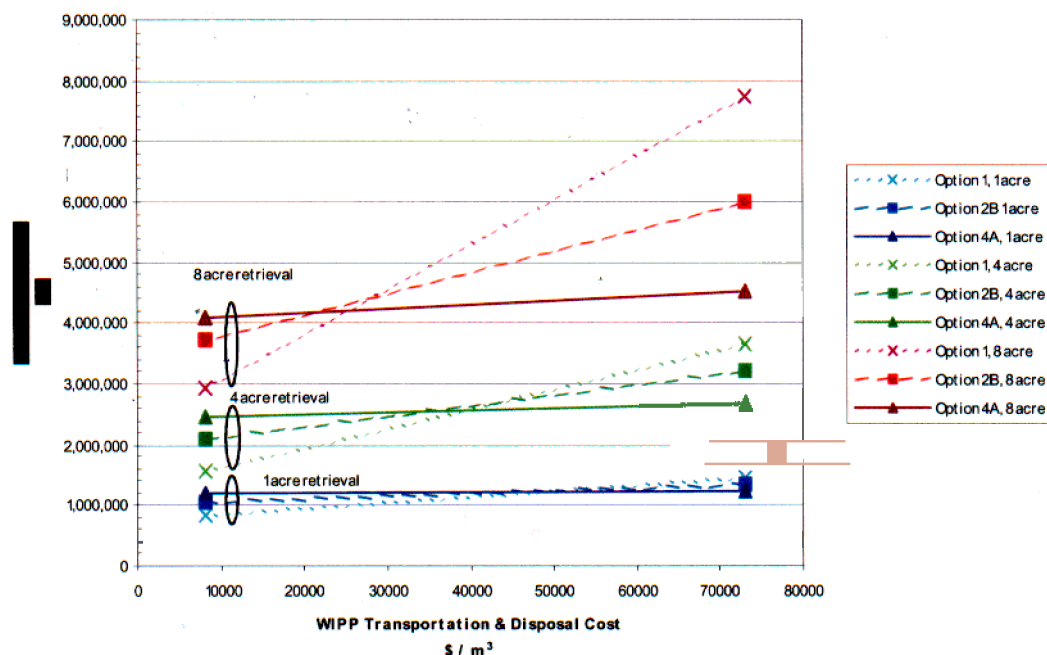


Figure 25. Life-cycle costs for the three alternatives, given retrieval areas and WIPP disposal costs.

The data points on the left hand side of Figure 26 show that Alternative 1 (Compact All) has the lowest life-cycle cost for any retrieval area, providing the low WIPP disposal costs are used. However, when the high WIPP costs are used (right hand data points), this same alternative becomes the most expensive in all cases. For increasing retrieval areas, the differences between the alternatives on either side of the graph are accentuated and cross-over-point (the disposal cost at which the lower volume reduction and lower capital cost) alternatives become more expensive than the high volume reduction case shifts to the left. In other words, as the retrieval area increases, the WIPP disposal cost becomes a larger fraction of the total cost and the unit cost at which the total disposal cost outweighs the capital and operating costs is less. When TRU waste disposal costs are at least \$45,000/m³, treatment to reduce waste volume begins to be cost effective for even the one pit retrieval. However, the technical uncertainties associated with the alternatives must also be considered. If the relatively small difference in the 1 acre retrieval curves at \$45,000, disposal costs would likely not outweigh the technical risks. On the other hand, if large retrieval volumes are considered, the cost savings of Alternative 4a will more than offset its technical risk.

The engineering schedules shown for the three alternatives in the previous sections all meet the initial 10% design submittal enforceable deadline. They are expected to start construction on or before the March 31, 2007, date. Only Alternative 1 starts operations by the mandated 36 months after the start of construction, which requires that site preparation, utility work, and initial excavation do not trigger the start of construction enforceable deadline. As currently conceived, the schedules for Alternatives 2b and 4a do not meet the start of operations deadline.

Again, it should be noted that these construction schedules were based on planning level designs and have not been optimized. As the designs develop, constructability reviews will be held to assure that features to speed construction are incorporated in the design where feasible. However, it is anticipated that starting Alternative 1 36 months after start of construction will be challenging, and in the cases of Alternative 2b and 4a, much more challenging yet. Table 16 contains a summary of major enforceable deadline submittals for the three alternatives.

Table 16. Summary of major deadline submittals for the three treatment alternatives.

Alternative	Submit 10% Design Enforceable Deadline (September 2005)	Start Construction Enforceable Deadline (March 31, 2007)	Start Operations Enforceable Deadline (36 months after start of construction)
1	September 30, 2004	March 31, 2007	March 31, 2010
2b	September 30, 2004	March 31, 2007	September 1, 2011
4a	September 30, 2005	June 28, 2008	June 29, 2014

Modifying Criteria

Evaluation of modifying criteria will be addressed in future Pit 9 Remediation Project CERCLA documents.



5. RISK

Part of the constraint/assumption process included identifying programmatic and technical risks and establishing mitigation strategies for handling those risks. The risk management process to be used during execution of the Pit 9 Remediation Project follows the general risk management process described in DOE Manual 413.3-1, Chapter 14, “Risk Management.” However, it is tailored to suit its size, complexity, and unique attributes of the Pit 9 Remediation Project, and will be performed at each project phase to support critical decision approvals.

At the current stage of the project, the emphasis is placed on planning and risk identification. The planning phase of the risk management process has been accomplished with the release of the Risk Management Plan (PLN-1358, *Risk Management Plan for the OU 7-10 Stage III Project*, Rev. 1). The risk identification process is currently underway. The major risk areas that would significantly affect the project performance if they were not resolved are provided in Table 17. These risks are divided into three categories (programmatic, technical retrieval, and technical treatment) and include the expected risk response strategy for each risk item.

Table 17. Pit 9 remediation risks

Risk Type	Major Risk Concern Areas	Risk Handling Strategy
Programmatic	The agencies may not approve the proposed change to the TRU action level.	Reduce
	The agencies may not approve the proposed change to the volume reduction goal.	Reduce
	The agencies may not approve the proposed changes to the treatment technologies to be used for the OU 7-10 remediation (as specified in OU 7-10 Record of Decision).	Reduce
	An alternate TRU pit or trench may be selected for Stage III retrieval.	Mitigate
	The Stage III remedial action objectives will not be finalized until late into the design phase.	Mitigate
	There is a significant likelihood that one or more ARD deadlines will be missed for the low-complexity, baseline treatment alternative due to a lack of schedule buffer, a multipath critical path (with many near-critical paths), and the inherent variability of activity durations. It is a near certainty that the ARD operations commencement deadline will be missed given the adoption of a high-complexity treatment alternative such as chemical leaching.	Reduce
Technical Retrieval	The agencies may not approve the proposed exemption from retrieving remote-handled waste items in the pit.	Reduce
	The agencies may not approve the proposed exemption from retrieving “large-object” waste items in the pit.	Reduce
	The retrieval approach could change significantly if the condition of the buried waste retrieved during the Glovebox Excavator Method Project indicates high container integrity.	Mitigate
Technical Treatment	The agencies may not approve the proposed exemption from retrieving remote-handled waste items in the pit, or a remote-handled waste item is inadvertently passed to treatment.	Reduce and mitigate
	Volume fraction estimates and timing assumptions for TRU waste, soil contaminated to TRU-waste levels, non-TRU waste, and non-TRU soil entering treatment may, over time, prove inadequate as a basis for scaling the treatment unit operations.	Reduce
	The agencies make a determination that the waste receiving and preparation function, as defined in the preconceptual design, constitutes Resource Conservation and Recovery Act (RCRA) placement, thereby, triggering land disposal restriction requirements to be met for all waste to be returned to the pit.	Reduce and avoid
	The nondestructive assay technology(ies) selected for use in Stage III may not be capable of meeting WIPP accuracy and certification requirements.	Reduce



6. PATH FORWARD

The conceptual design for the Pit 9 remediation process, which will include the selected retrieval and treatment alternatives, will be developed in FY 2004. The conceptual design will apply systems engineering and value management processes to ensure that the selected retrieval and treatment alternatives documented in the conceptual design report support the mission need, are cost effective, and provide the best benefit to DOE. Consistent with systems engineering practice, requirements are currently being identified and will continue to be updated in greater detail as the project proceeds. This requirements definition effort includes coordination and discussion between NE-ID, EPA, and IDEQ. Efforts are currently underway and will continue in FY 2004 to evaluate the TRU action level and the volume reduction requirements previously established in the *Pit 9 Interim Action ROD* with respect to risk and cost, to determine whether there is a basis for modifying the ROD requirements.

Value management techniques will be used, where applicable, to evaluate improvements to retrieval and treatment alternatives that can be made in a timely manner with a minimum of rework. The recommended alternatives will continue to be developed to the appropriate level of detail needed for use as bases in project performance ranges that meet cost and schedule estimates proposed in Appendix B. The design concepts developed during this phase will be used as bases for related efforts, especially risk analysis and preliminary documented safety analyses. Although a risk management plan has been developed for this process, risk identification and mitigation efforts will continue.

The conceptual design for the Pit 9 Remediation Project will be submitted in FY 2004 in compliance with the ARD mandated deadline.



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